SEED GERMINATION RESPONSE OF *ZIZANIA TEXANA* (POACEAE: ORYZAE) TO SOIL INUNDATION

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ABSTRACT

Although the current distribution of *Zizania texana* (Texas wild rice) supports the theory that this species requires flowing water for stable existence, historical documents describe the plant as growing bank to bank within the San Marcos River, Hays County, TX, U.S.A. This may mean that, at times, *Z. texana* grew without flowing water or germinated in saturated, but not inundated soils. In this study, I determine if *Z. texana* requires water-inundated soil for successful seed germination. I found that although some seeds will germinate without inundated soils, the germination success of the groups of seeds tested in inundated soils was significantly higher ($p < 0.01$) than those tested in only saturated soils. The results of this study may help with future restoration and recovery of this endangered species.

RESUMEN

A pesar de que la distribución actual de *Zizania texana* (arroz tejano silvestre) en peligro de extinción respalda la teoría de que esta especie requiere agua corriente para su existencia estable, documentos históricos describen esta planta creciendo de ribera a ribera en el Río San Marcos en Hays County, TX, USA. Es posible que esto indique que, en algunas ocasiones, *Z. texana* creció sin agua en circulación, o germinó en tierras saturadas pero no inundadas. En este estudio, se determinó si *Z. texana* requiere tierra inundada para el éxito en su germinación. Encontré que a pesar de que algunas semillas germinan sin tierras inundadas, el éxito de germinación de grupos de semillas puestas a prueba en tierras inundadas fue significativamente más alta ($p < 0.01$) que aquellas probadas en tierras saturadas. Los resultados de este estudio puede que ayude en los esfuerzos futuros de restauración y recuperación de esta especie en peligro de extinción.

INTRODUCTION

Ecophysiology of seed germination is very important for the conservation of endangered species as it is a key factor of reproduction and will therefore strongly aid in restoration strategies. For aquatic and wetland plants, it is essential to know if germination rates are affected by soil water-levels (Sifton 1959; van der Valk 1981; Keddy & Ellis 1985; Kellogg et al. 2003). This information will help in making decisions regarding where in an aquatic system seeds should be planted.

There are three species in the genus *Zizania* L. in North America: *Z. aquatica* L., *Z. palustris* L., and *Z. texana* Hitch (Terrell et al. 1997). Each of these species grow in aquatic environments, but *Z. texana* may require flowing water for stable existence (Power 1996; Poole & Bowles 1999), while the other species can be found in stagnant water on the edges of lakes or along muddy shores of slow-moving streams that are subject to constant changes in water levels (Archibold & Weichel 1986; Pip & Stepaniuk 1988). *Zizania texana* is a federally listed endangered species endemic to the San Marcos River, San Marcos, Hays County, Texas, U.S.A. The distribution of *Z. texana* is restricted to the upper 2.4 km of the river, within mean water depths ranging between 0.72 to 0.83 m, and mean velocities ranging between 0.38 to 0.93 m/s (Poole & Bowles 1999).

Historical documents that portray *Z. texana* growth in the San Marcos River describe the plant as growing bank to bank, including irrigation waterways (Silveus 1933; Terrell et al. 1978). The San Marcos River is spring-fed and river flow relies on the spring outflow as well as runoff. When outflow and runoff are low, such as during times of drought, the area near the banks may not always be covered by water. This may mean that, at times, *Z. texana* grew without flowing water or germinated in non-inundated soils. The purpose of this study was to evaluate the response of seed germination of *Z. texana* to soil inundation. For this study, I test the hypothesis that *Z. texana* seeds need to be in inundated soil for successful germination.

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MATERIALS AND METHODS

Approximately 3,375 cm^3 of soil consisting of one third pea gravel to two thirds of an equal mixture of compost, top soil and sand was placed into each of 10, 45 × 30 × 13 cm clear plastic rectangular containers. Soil mixtures were saturated with water from the Edwards aquifer (the same water source as the San Marcos River) until the point at which pooled water just began to become visible on top of the soil. Seeds used for the study were collected randomly from container grown plants growing in the San Marcos National Fish Hatchery and Technology Center that were initially collected from the San Marcos River following techniques recommended by Richards et al. (2007) for the best genetic representation of the wild population. We used a total of 50 seeds for this study. Because this endangered plant has such a small population size, there are only a small number of seeds available for scientific studies. The seeds were collected four months prior to the experiment, in September 2006, and preserved in a refrigerator at 4 °C in moist paper towels within sealed plastic bags, allowing for optimal germination conditions (Rose & Power 2001). Lemna and palea were kept intact as their presence does not change germination probability and as it also mimics the natural condition in this species (personal observation). Five seeds of approximately equal size were placed equidistant to each other (5 cm apart) in the containers of saturated soil at a ¼ cm depth. All containers were placed into a growth chamber set to a 12-hour photo period at 20 – 23 °C. Water was added slowly to the five containers receiving the inundated treatment until it covered the soil with 2.5 cm of water. Each inundated treatment was paired next to a non-inundated treatment within the growth chamber. Every 24 hours, any water loss within the 10 containers was compensated for, seeds were visually examined for signs of germination, and the total number of germinated seeds was recorded. Seeds were considered to have germinated when the radical had visibly emerged from the pericarp. Since Power and Fonteyn (1995) found that most seeds of *Zizania texana* germinate within a 10-day period, following a 4-week period of daily visual examinations the study was terminated. A paired t-test was run in order to determine if there is a significant difference between the germination success rates of the two treatments, non-inundated and inundated (analysis performed using SYSTAT v.10 statistical package).

RESULTS

Sixteen of the 25 total seeds in inundated soil and four of the 25 total seeds in non-inundated soil germinated within the 4-week period (Fig. 1). Germination success was greater in inundated soil than in non-inundated soil (paired $t = 4.7$, $df = 8$, $p = 0.009$; Mean difference = 2.4; 95% C.I. = 0.98 to 3.82).

DISCUSSION

In this study, more *Z. texana* seeds germinated in inundated soil than in non-inundated soil. This may be because *Z. texana* seeds are recalcitrant and do not survive for long outside of water (Horne & Kahn 2000). The seeds may more readily germinate in inundated soil than in non-inundated soil because *Z. texana* are so sensitive to desiccation.

Zizania texana is considered a perennial grass (Terrell 2007). In its current distribution within the San Marcos River, *Z. texana* plants are, for the most part, submerged year round (personal observation) and rarely flower (Emery 1966, 1977). There is a possibility that the species has an annual form as well in certain environments. This species is a CO_2 obligate (Power & Doyle 2004). It may remain in perennial form if growing in current velocities such that the boundary layer surrounding the leaves is small enough to take in CO_2 for photosynthesis. However, if in stagnant, or slow moving currents, an individual plant may become emergent in order to take in CO_2 from the air (where it is much more abundant), flower, seed, and then die (i.e., annual growth form). If this species were to grow in its historic range of bank to bank, it may be possible that some of the plants would become annuals and grow in areas of low flow and shallow water. Because the seeds do not germinate as well in non-inundated soil, the San Marcos spring-flow has to continue to be high enough (>100 cubic feet per second) that the soil at the banks' edge is consistently inundated. Currently, *Z. texana* is inhibited from growing along the shallow, low flow banks because *Colo-*

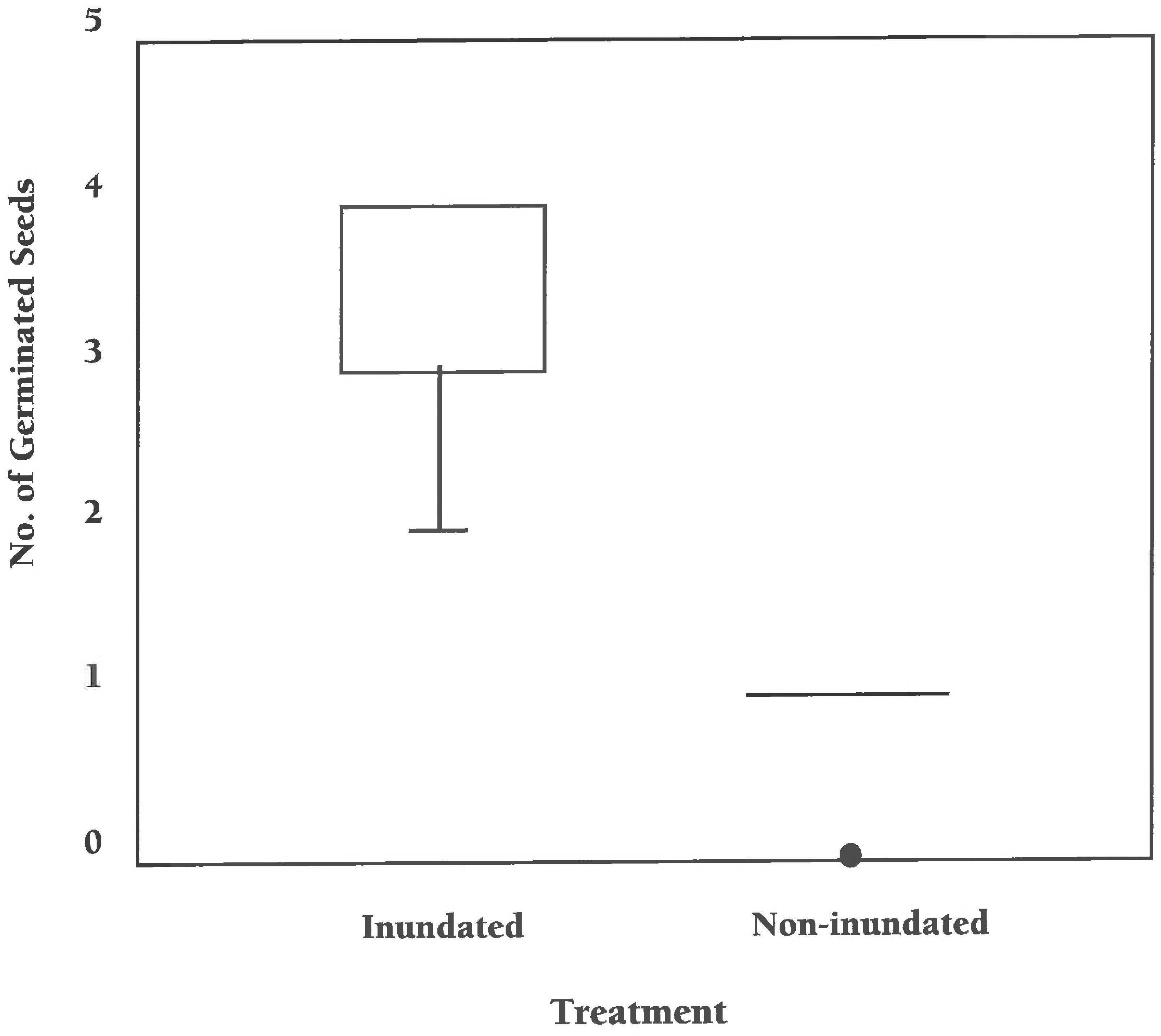

Fig. 1. A box plot portraying the median number of germinated *Zizania texana* seeds in the five containers for each treatment (inundated and non-inundated soil), corresponding quartiles and outliers.

casia esculenta (wild taro) has invaded and dominated the edges of the San Marcos River (Akridge & Fonteyn 1981; Nelson & Getsinger 2000).

The results of this study will aid in future restoration efforts for this endangered aquatic plant. With data that supports the planting of seeds in inundated soil, all areas chosen for planting should be covered in water during average spring flows. Restoration efforts of *Z. texana* should include planting in both low and high flow areas to support both perennial and annual forms of the plant. This would have to include the removal of *C. esculenta* in order to make the river-edge habitat available for the endangered *Z. texana*.

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